Space Weather Technical Forecast

Issued on Saturday, 02 September 2023 at 13:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Moderate storms expected 02-03 Sep due to HSS and CME arrivals, with the potential for further activity 04-05 Sep. Chance of M-flares (R1-R2 Radio Blackout) 02 Sep, decreasing 03 Sep onward.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with a further long duration M3.3 flare from AR3413 in the northwest, peaking at 02/0712UTC, with an associated CME. This is the largest and most complex region on the disc, but due to approaching the northwest limb is becoming increasingly hard to assess. Of the other sunspots AR3417 also has some complexity, consisting of a number of mature small negative spots, but has only seen minimal growth in trailer positive spots. AR3413 remains a simple bipolar region in the southeast, whilst AR3416 and AR3418 are small unipolar spots. The small, recently numbered AR3419 region has emerged in the northwest, to give six sunspots in total.

The CME produced by the M1.2 flare on the 01 Sep is moderately fast, but with the bulk of the material mainly directed north and ahead of Earth. However, arrival is anticipated around 03/0600 UTC. A further CME was also observed due to a small eruption from AR3413 in the southwest disc at 01/0620 UTC. This has been analysed as a slower and weaker CME, largely passing ahead and south of Earth, but with a chance of a glancing impact on day 3 (03 Sep). Further CMEs have been observed, with a CME associated with the recent M3.3 flare from AR3413 awaiting analysis.

Solar Wind / Geomagnetic Activity: Ongoing fast wind influence was observed, with a likely transition into the main core of fast winds from CH40/+ occurring. Solar wind speeds observed by ACE at L1 were initially 400-450 km/s, but fairly rapidly increased 01/1750-1830 UTC to become 500-600km/s. A further increase to approximately 700km/s was recorded from around 02/0400 UTC, declining slightly by the end of the period with DSCOVR observations becoming unreliable. Density was at average levels to start, then decreased to be below average from around 01/1800 UTC. Despite this, the total Interplanetary Magnetic Field (IMF), Bt, persisted Weak to Moderate around 5-11nT, with the north-south direction, Bz, remaining variable between +9 nT and -10nT. Phi angle positive (away from the Sun) to start but became highly variable from around 02/0400 UTC. Geomagnetic activity was Quiet to Active (Kp 1-4, with the Kp4 interval 01/1200-1500 UTC) initially, but became Active from 02/0000 UTC, with a G1 minor storm (Kp 5) interval recorded 02/0600-0900 UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at S1 Minor Radiation Storm levels between 01/1200 UTC and around 01/2000 UTC. Observed flux has subsequently been gradually and erratically easing but remains above background levels. GOES16 high energy (greater than 2MeV) electron flux was at background. The associated 24-hour fluence was well below the Active threshold, with 1.31e6 integrated pfu observed at 02/0000 UTC.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity day 1 (02 Sep), with a further risk of M-flares from AR3413. This activity is expected to ease day 2 (03 Sep) onward, as AR3413 rotates over the northwest horizon, with the other spots on the disc currently smaller and simpler.

Solar Wind / Geomagnetic Activity: There are two main CMEs, and a further small glance possible in the forecast. The first is expected to arrive 02/2200 UTC +/- 9hours and is from the filament eruption on 30 Sep. The second is expected to arrive 03/0600 +/- 9hours, and is from the moderately fast CME which occurred alongside the M-flare of AR3413. A further small glance is possible on day 3 (3 Sep) from the subsequent small CME from AR3413 which left the Sun around 01/0600 UTC.

Generally Active conditions with G1 Minor Storm intervals are expected at first due to the ongoing HSS and potential CME arrivals. The first arrival is expected to bring a chance of G2 Moderate storms from late day 1 (02 Sep), before the second CME arrives early day 2 (03 Sep), with isolated G1-G2 Minor to Moderate storms expected, and a slight chance of G3 Strong Storms. This activity is likely to ease day 3 (04 Sep), however potential ongoing CME and HSS effects may bring further G1 Minor Storms with a slight chance of G2 Moderate storms. Activity then easing further day 4, to mainly Unsettled, but with a chance of Active to G1 Minor storm intervals given the potential for further enhancement associated with the HSS of CH42.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to slowly decline towards background levels, with a slight chance of further enhancements, perhaps above the S1 level given potential CME arrival or any further flaring of AR3415 over day 1-2 (02-03 Sep). High energy (greater than 2 MeV) electron flux is expected to be suppressed due CME arrivals, before potentially rising as solar wind pressure eases later day 2 and day 3. A chance of Moderate to High flux by day 3, but more likely day 4 (04-05 Sep).

The associated 24 hour fluence is expected to remain below the Active level (1e8 integrated pfu) at first, but with an increasing chance of rising above by the end of day 4 (05 Sep).

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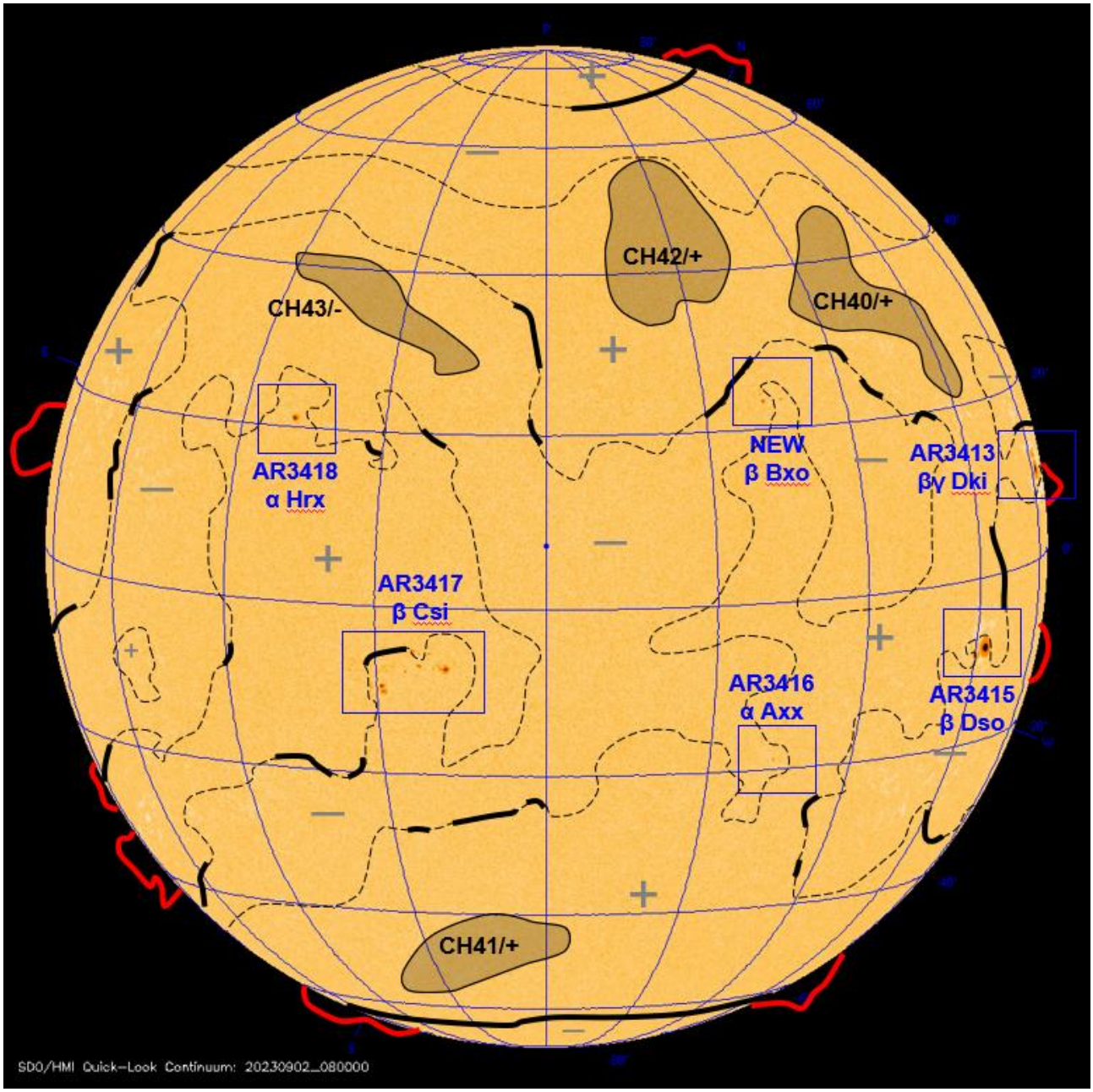
Figure 1. Solar Analysis Valid 02/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Two main CME arrivals feature in the forecast. The first from a filament eruption on 30/2000 UTC, forecast to arrive day 1 at 02/2200 UTC +/- 9hrs. The second is associated with the M-flare of AR3413 which peaked 01/0352 UTC. This is currently anticipated to give a more glancing arrival day 2, 02/0600 UTC +/- 9 hours. There is also a third CME that followed this eruption, from AR3415 around 01/0620 UTC, this is a much weaker event, and likely only be a more glancing impact, but given the already disturbed environment, has the potential to increase activity again on day 3 (04 Sep).

Solar winds are currently elevated to strong, around 550-650km/s, with an ongoing fast wind influence likely due to the high speed stream (HSS) associated with CH40/+. This may ease a little before potential first CME arrival later day 1 or early day 2. The second arrival is then expected to follow, with the potential for solar winds once again reach strong levels. Solar winds may gradually ease day 3, however this is lower confidence with conditions likely remaining dominated by the CME influence, with the potential for a further weak CME glance. Further enhancement is likely into day 4 (05 Sep) from the influence of CH42/+, also in the northern hemisphere.

Generally Active conditions with G1 Minor Storm intervals are expected at first due to the ongoing HSS and potential CME arrivals. The first arrival is expected to bring a chance of G2 Moderate storms from late day 1 (02 Sep), before the second CME arrives early day 2 (03 Sep), with isolated G1-G2 Minor to Moderate storms expected, and a slight chance of G3 Strong Storms. This activity is likely to ease day 3 (04 Sep), however potential ongoing CME and HSS effects may bring further G1 Minor Storms with a slight chance of G2 Moderate storms. Activity then easing further day 4, to mainly Unsettled, but with a chance of Active to G1 Minor storm intervals given the potential for further enhancement associated with the HSS of CH42.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	80	80	60	30
Strong	G3	No	10	20	10	5
Severe	G4	No	1	5	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
31/0305	Partial	Filament	NW disc, but heading SE	610 km/s	02/2200 +/- 9 hrs	Nil
01/0625	Partial	M1.2 AR3415	NW disc	1125 km/s	03/0600 +/- 9 hrs	Nil
01/1129	Nil	C2.8 AR3413	SW disc	431 km/s	04 Sep	Very low confidence.

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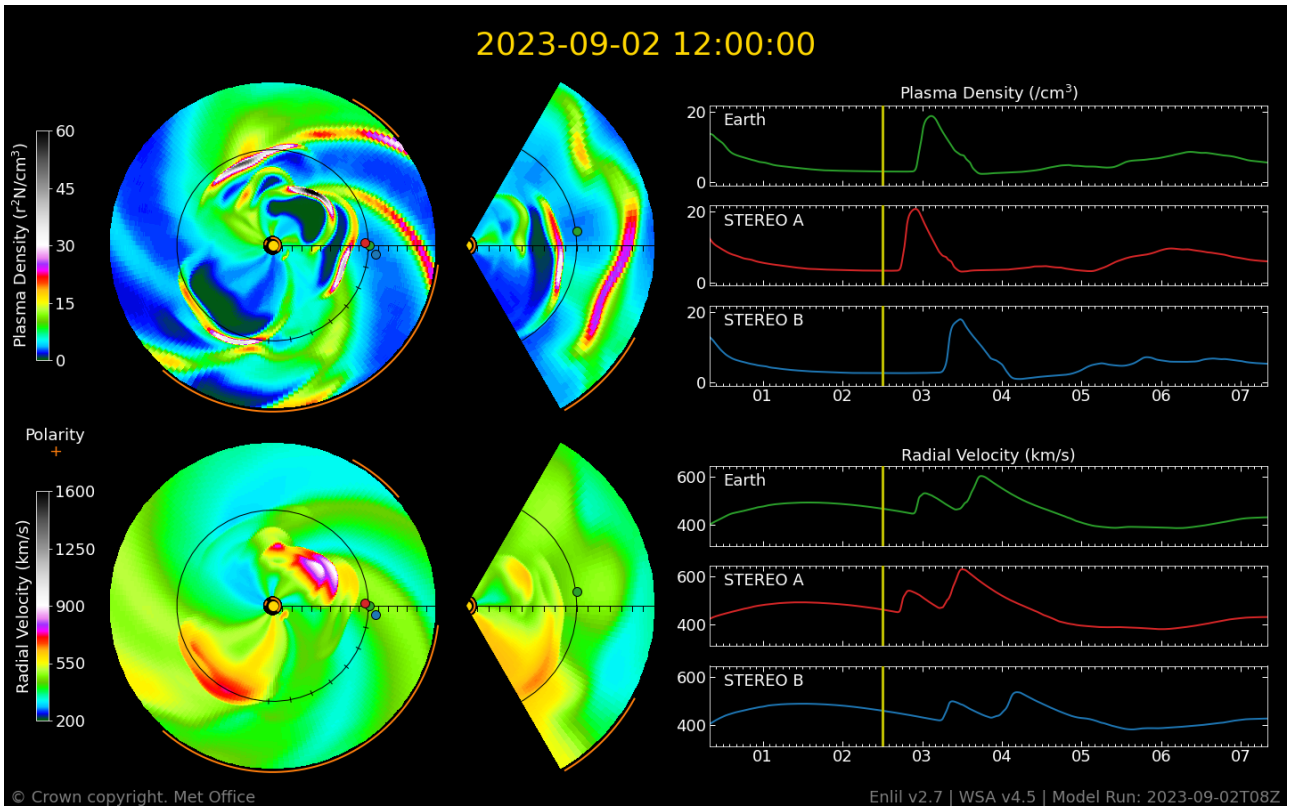
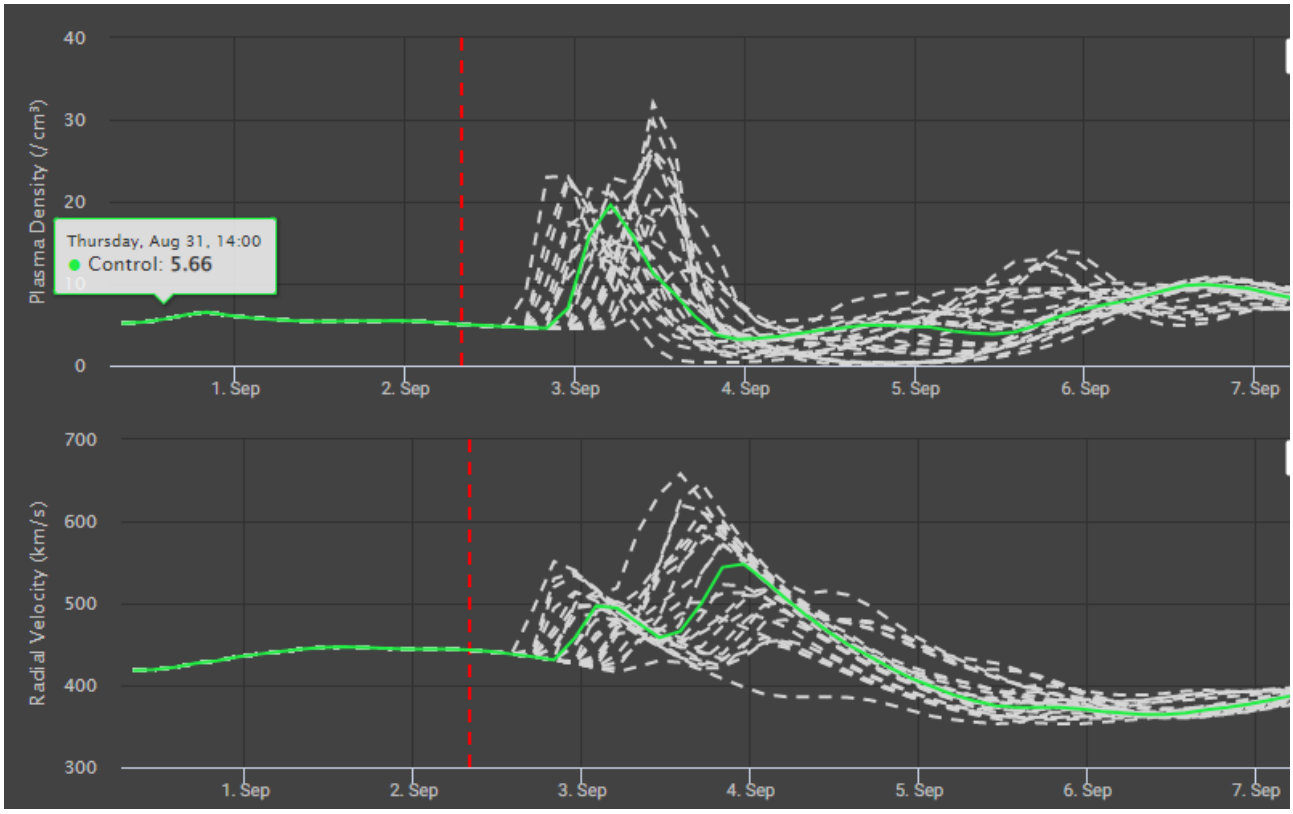
Figure 2: Latest MOSWOC Enlil output showing two potential CME arrivals, with ensemble. Any impact of third CME is generally swamped by the ongoing conditions. Note current output under representing current solar winds associated with CH/40+ and this is likely to persist into the forecast period.





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Radio Blackouts - X-Ray Flares:
Moderate activity expected day 1 (02 Sep) with AR3413 showing ongoing potential for further M-flares. Any changes to this region are difficult to assess as it approaches the northwest limb, but after a further long period M3.3 flare on 02 Sep, active looping remains visible in SDO-aia imagery (e.g. 211). This region will rotate over the northwest horizon early day 2 (03 Sep), with the M-flare risk subsequently decreasing.

There are four other numbered active regions on the disc, however the majority of these are small and/ or stable. The main exception is AR3417 which is a slightly more atypical group consisting of a number of small negative polarity spots with penumbra, but only very small positive spots currently without penumbra. Despite this, there is a reasonable magnetic canopy visible over the spot in SDO aia-imagery, and any further development would likely increase the M-flare potential. No other significant regions currently expected to rotate onto the visible disk during the forecast period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	40	30	20
Very Active	R3 to R5 X Class	No	5	2	1	1

Figure 3: Latest 24hr X-ray Flux, showing M3.3 flare from AR3413.

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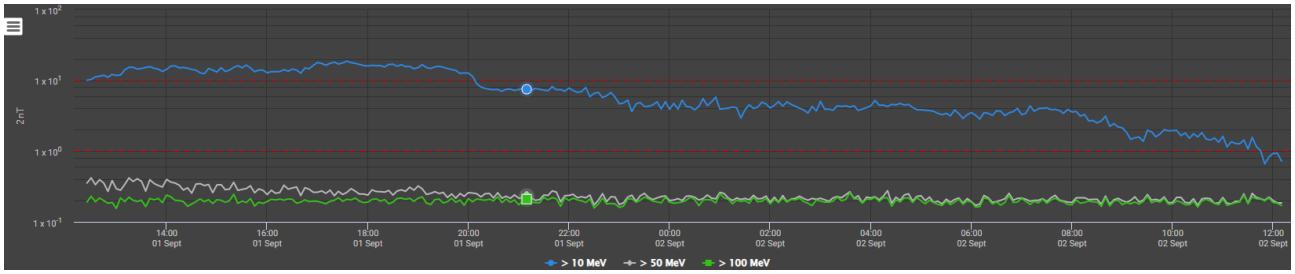
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES-16 remains above background, but has now fallen below the S1 threshold after the recent enhancement due to the M1.2 flare of AR3415 on 01 Sep.

Flux is likely to continue erratically declining, although a brief increase is possible ahead of any CME arrival later day 1 (02 Sep). Any further significant flares from AR3413 also have the potential to bring further enhancements to the flux, giving a slight chance of a further S1 event day 1, but decreasing through day 2 (03 Sep). As this region rotates further away on the far-side this risk subsides further, unless there is any further development of any of the sunspots currently on the disc, or any notable new sunspot emergence occurs.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	15	10	5	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Latest 24hr GOES16 Proton Flux



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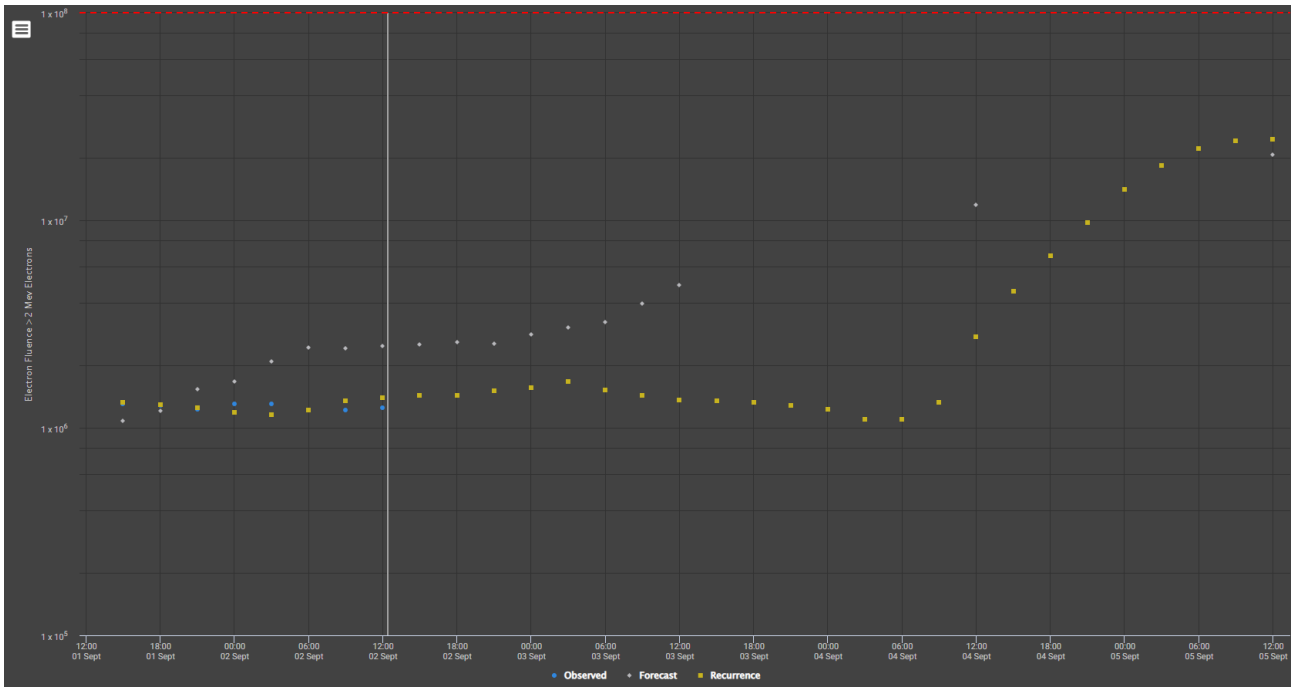
High Energy Electrons Event (≥ 2MeV):
There is low confidence in this forecast, as it is very dependent upon the strength of the anticipated CME arrivals later day 1, and again into day 2 (02-03 Sep).
High energy (greater than 2 MeV) electron flux observed by GOES16 is currently at background levels, perhaps rising to Moderate later day 1 (02 Sep) but a further drop out expected associated with the potential CME arrivals. Any CME arrival likely to increase electron populations throughout the Van Allen belts, but initially compressing them into lower orbits. As the solar wind pressure eases, mainly day 3 onward (04 Sep), flux seeing an increasing chance of become Moderate to High by day 4 (05 Sep). The potential for persistent fast wind enhancement and associated further suppression does act to lower forecast confidence significantly however.

The associated 24 hour fluence is expected be below the Active (1e8 integrated pfu) threshold day 1-2 (02-03 Sep), but with an increasing risk of rising above day 3 (04 Sep), and a chance of rising above day 4 (05 Sep). MOSWOC REFM is currently good guidance until the CME arrival, but predictive value may reduce into day 2 (03 Sep) depending on the detail of any CME arrival.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	10	30	50
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: Latest MOSWOC REFM model output



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